INFAUNAL ABUNDANCE IN RESTORED AND REFERENCE MARSHES OF THE NORTHWESTERN GULF OF MEXICO

A Senior Scholars Thesis

by

BRITTNEY LAUREN DAVIS

Submitted to the Office of Undergraduate Research
Texas A&M University
in partial fulfillment of the requirements for the designation as

UNDERGRADUATE RESEARCH SCHOLAR

April 2011

Major: Marine Biology

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Approved by:

Research Advisor: Anna Armitage
Director for Honors and Undergraduate Research: Sumana Datta

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ABSTRACT

Infaunal Abundance in Restored and Reference Marshes in the Northwestern Gulf of Mexico. (April 2011)

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One widely accepted approach to mitigate the loss of natural marsh habitat is to restore marshes in areas that were previously open water. To better understand the infaunal community within restored marshes, infauna were collected from a restored and reference brackish marsh in East Texas. The restored marsh was constructed using multiple methods to incorporate a variety of different morphologies. A one-way ANOVA was used to determine if significant differences in species richness and density existed among the habitat types. Sediment characteristics were also measured to address infaunal-sediment relationships. No significant differences were observed between habitat types for either average infauna abundance ($P = 0.654$) or species richness ($P = 0.748$). Additionally, no significant correlations were found for sediment and total infauna abundance. Similar infaunal communities in the reference and restored marsh suggests that the recovery of constructed marshes to reference conditions occurs in less than 4 years.

DEDICATION

I dedicate this thesis to my advisor, Dr. Anna Armitage,

from whom I have learned so much.

ACKNOWLEDGMENTS

Funding for this study was provided in part by the Texas General Land Office and Texas A&M University through the Texas Institute of Oceanography fellowship. I would like to thank Texas Parks & Wildlife for field support, the Wetlands Ecology Lab at TAMUG, and especially Cody Hales and Eric Madrid for help with the collection, analysis, and interpretation of data.

NOMENCLATURE

GOM	Gulf of Mexico
LNWMA	Lower Neches Wildlife Management Area

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CHAPTER I

INTRODUCTION

Marshes are ecologically productive habitats that support a wide variety of invertebrates, fish and waterfowl, act as filters for pollution, and protect the shoreline from erosion and hurricanes (Boorman 1999). Over half of the salt and brackish marshes in the northern Gulf of Mexico (GOM) have been reduced to open water. A widely accepted approach to mitigate the loss of valuable ecological services is the construction of new marsh habitat. Marsh construction methods include backfilling dredged canals (Baustian et al. 2009), terracing (Merino 2010), and using excavated soil or dredge fill to return areas of open water to marsh elevation. Despite the widespread implementation of these techniques in the Northwestern GOM, understanding of how they impact the ecology of a new marsh remains limited. Mitigation projects are usually considered successful within a few years because the current focus of most assessments is primarily given to plant canopy structure. However, the ecology of a marsh is not limited to its vegetation. Many other attributes are also important, including the establishment of an epibenthic and benthic community.

This thesis follows the style of Marine Ecology Progress Series.

Infauna are ecosystem engineers that decompose organic matter (Sandnes et al. 2000), oxygenate the soil (Blondin and Rosenberg 2006), and add trophic support for primary consumers (Whaley and Minello 2002). Studies of infaunal succession in constructed salt marshes along the Atlantic coast suggest that the infaunal community is slower to develop than the marsh plant canopy (Moy and Levin 1991; Sacco et al. 1994, Levin et al. 1996; Craft et al. 1999). For example, in a survey of two constructed salt marshes in North Carolina, Craft et al. 1999 reported that above ground biomass of *Spartina alterniflora* was equivalent with that of a nearby reference marsh after only 3 years but that infaunal communities weren't comparable until 15-25 years after marsh establishment.

Notable differences in infauna trophic composition and mean densities has also been reported for reference and constructed marshes (Moy and Levin 1991; Levin et al. 1996; Craft and Sacco 2003). Moy and Levin (1991) found that in a constructed marsh less than 3 years old, the infauna community was dominated by polychaetes while surrounding reference marshes were dominated by oligochaetes. For plots planted with *Spartina alterniflora*, Levin et al. 1996 reported that densities of infauna remained significantly lower than in the reference after 4 years.

The extent to which a constructed marsh resembles a reference marsh in terms of structural design and sediment characteristics strongly influences the infaunal community. The objective of this study was to evaluate the influence of marsh construction methods on the infaunal communities in a restored marsh. I assessed the infaunal community by comparing mean infaunal density and species richness in the restored and reference marshes. Additionally, the influence of sediment on infaunal communities was examined by comparing mean densities to organic carbon content and other properties. I hypothesized that the construction method that included the most organic content would support the largest infaunal community.

This research will provide valuable insight into whether the construction techniques employed during the creation of a new marsh impacts infaunal density and species richness. My data will also expand our understanding of infaunal communities in brackish marshes of the GOM since existing research has been predominantly been in salt marshes along the Atlantic coast.

CHAPTER II

METHODS

Site description

The project site was a brackish marsh located within the Lower Neches Wildlife Management Area (LNWMA) in Port Arthur, TX USA (Fig.1). As part of the Chenier Plain drainage basin, the natural marsh was historically influenced by fresh water. Increased channelization following the 1950s and canal maintenance events between 1980 and 2007 led to the introduction of salt water, which subsequently killed approximately 600 acres of emergent vegetation.

In a case of off-site mitigation Chevron initiated restoration in 2008. The restored marsh was constructed using multiple methods that incorporate a variety of shapes and sediment type(s) (Fig. 2). *Excavated mounds* were created by excavated adjacent benthic sediment. *Filled mounds* were also constructed using benthic sediment but received additional inputs of dredge fill from a nearby canal. To create the *pumped mounds*, dry dredge fill from an upland disposal site was pumped on top of benthic sediment. The final water depth surrounding the excavated mounds was greater than for the filled or pumped mounds. *Terraces* were constructed similar to the *excavated mounds* but were built around each restoration site to protect against erosion caused by the surrounding open water areas. After construction the restored marsh was planted with the Vermilion strain of *Spartina alterniflora,* which is ideal for its salt tolerance and rapid canopy development. Remnant natural marsh to the south was used as the reference marsh. The four construction methods used in the restored marsh along with the natural marsh represent five treatments, which I refer to as “habitat types”.

Infauna collection

Samples were collected twice in October 2010 when seasonal densities were expected to be high (Whaley and Minello 2002). Sediment cores (7 cm deep x 4 cm wide) were taken from 10 randomly selected mounds in each habitat type. The cores were returned to the laboratory in plastic bags and rinsed through a 0.5mm sieve using tap water. Any material remaining on the sieve was placed into a 7.5% solution of $MgSO_4$, fixed with 10% formalin, and stained with rose bengal. The $MgSO_4$ solution anesthetized the organisms to prevent contraction into an unidentifiable state (Wilson 2005) and the rose bengal stain improved infaunal visibility and reduced the time required for sorting (Mason and Yevich 1967). The fixed organisms were sorted, identified to family, counted, and preserved in 70% EtOH.

Soil analysis

Separate cores taken from each habitat type in September 2010 were used for the soil analyses. The core for below ground biomass (20 cm deep x 6.35 cm wide) was rinsed through a 1.0 mm sieve. The plant material remaining on the sieve was dried to constant mass at 70°C for 6-7 days and weighed. A second core (10 cm deep x 3.81 cm wide) was divided for measurements of organic, inorganic, and total carbon, nitrogen, and phosphorus. Total carbon and inorganic carbon content were measured using a Costech Instruements elemental combustion system before and after loss on ignition at. 500°C. Organic carbon was obtained by subtracting the value for inorganic carbon from the value for total carbon. Total nitrogen content was also measured using the elemental combustion system. Total phosphorus was measured determined by a dry-oxidation, acid hydrolysis extraction followed by a colorimeteric analysis.

Statistical analysis

A one-way analysis of variance was used to test the hypothesis that habitat type influences the infaunal community, where total densities and richness were the dependent variables. Standard linear regressions were also performed to see if a correlation existed between sediment and total infaunal densities.

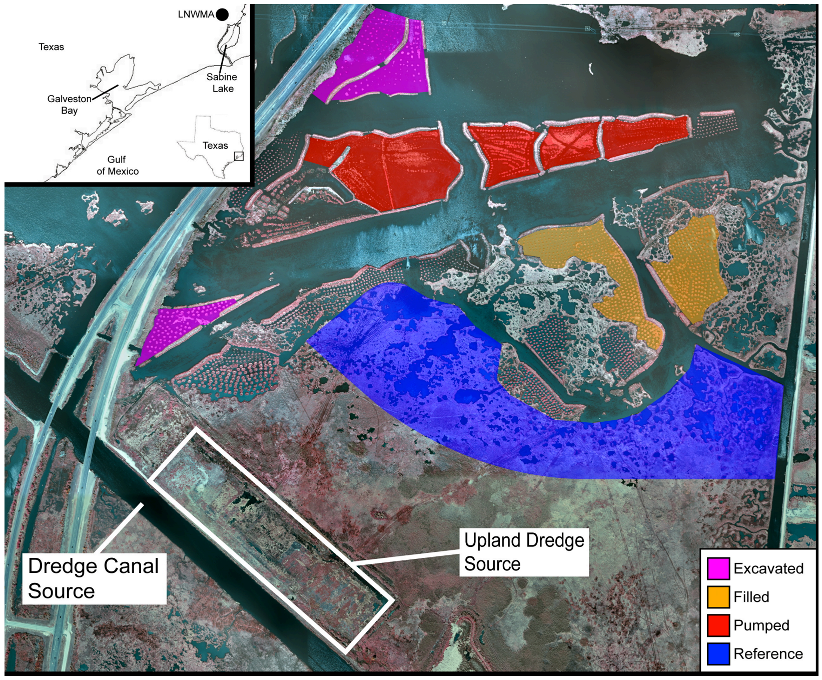

Fig. 1. Field sites for the LNWMA. Terraces are not highlighted but surround the excavated, filled, and pumped sites.

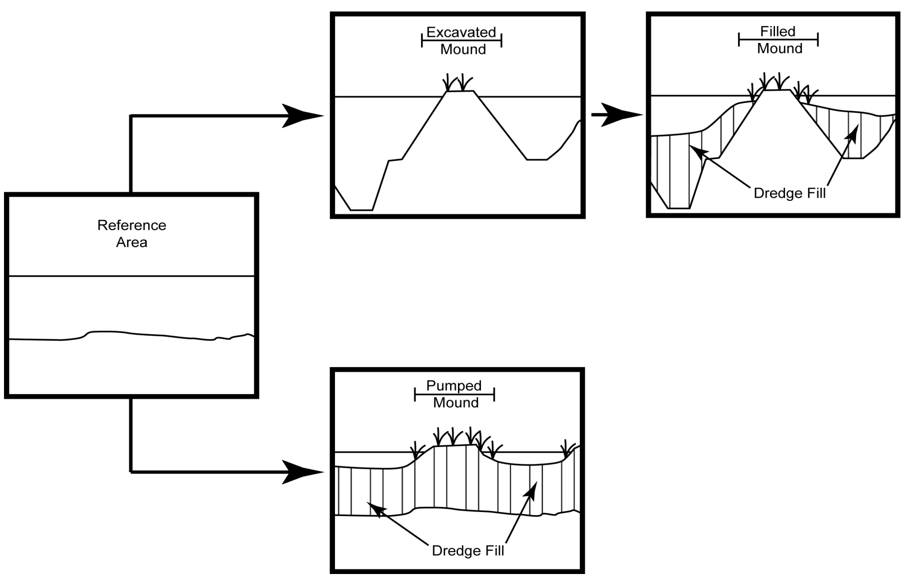

Fig. 2. The construction techniques used in the restored marsh. Terraces were built similiarly to the excavted mounds so are not included.

CHAPTER III

RESULTS

A total of 4 taxa were identified to family. They were exclusively from the phylum annelida and are Amphartidae, Capitellidae, Nereididae, and Spionidae. Capitellidae and Nereididae were most abundant taxa in both the constructed and reference marshes (Table 1).

Total mean densities of infauna in the restored and reference marshes were 438 - 1754 individuals m^{-2} and 1532 indiv. m^{-2}, respectively. No significant differences existed between habitat types for either mean densities or species richness ($p = 0.654$; Fig. 3) or mean densities ($p = 0.7482$; Fig. 4). No significant correlations were observed between the sediment and mean infauna densities as well (Figs. 5-10).

Table 1. Total densities (m^{-2}) for each taxa ientified in the reference and restored sites.

Taxon	Reference	Excavated	Filled	Pumped	Terrace
Phylum Annelida					
Ampharetidae	219.3	0	0	0	0
Capitellidae	654.8	438.6	219.3	219.3	657.8
Nereididae	219.3	1315.7	219.3	219.3	219.3
Spionidae	438.6	0	0	0	0
Total	1532	1754.3	438.6	438.6	877.1

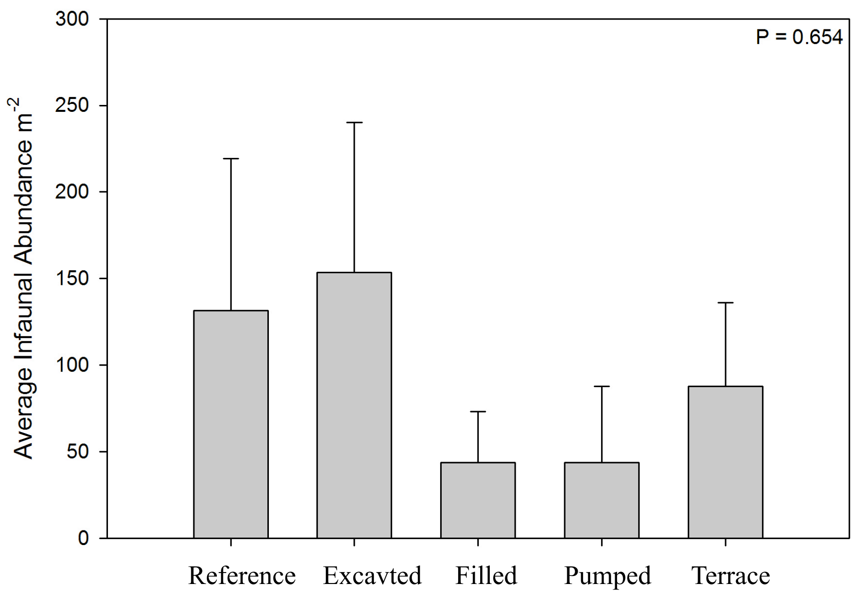

Fig. 3. Average infaunal abundance (m^{-2}) for each habitat type.

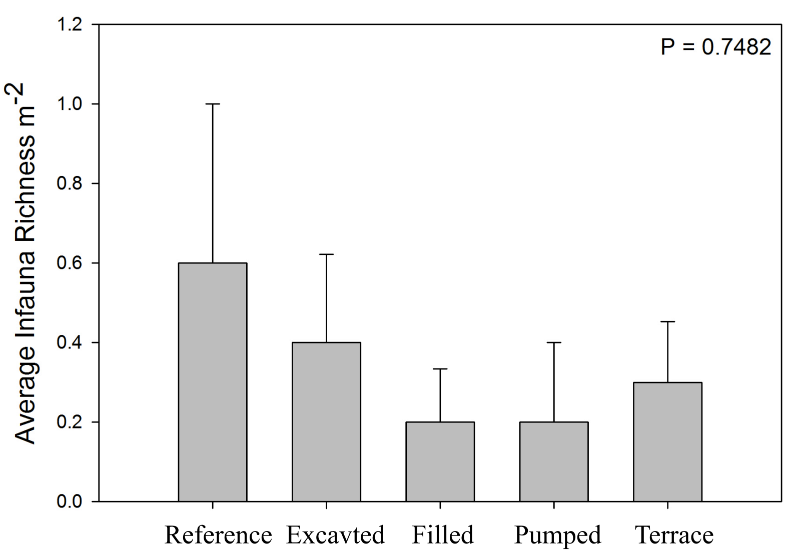

Fig. 4. Average infaunal species richness (m^{-2}) for each habitat type.

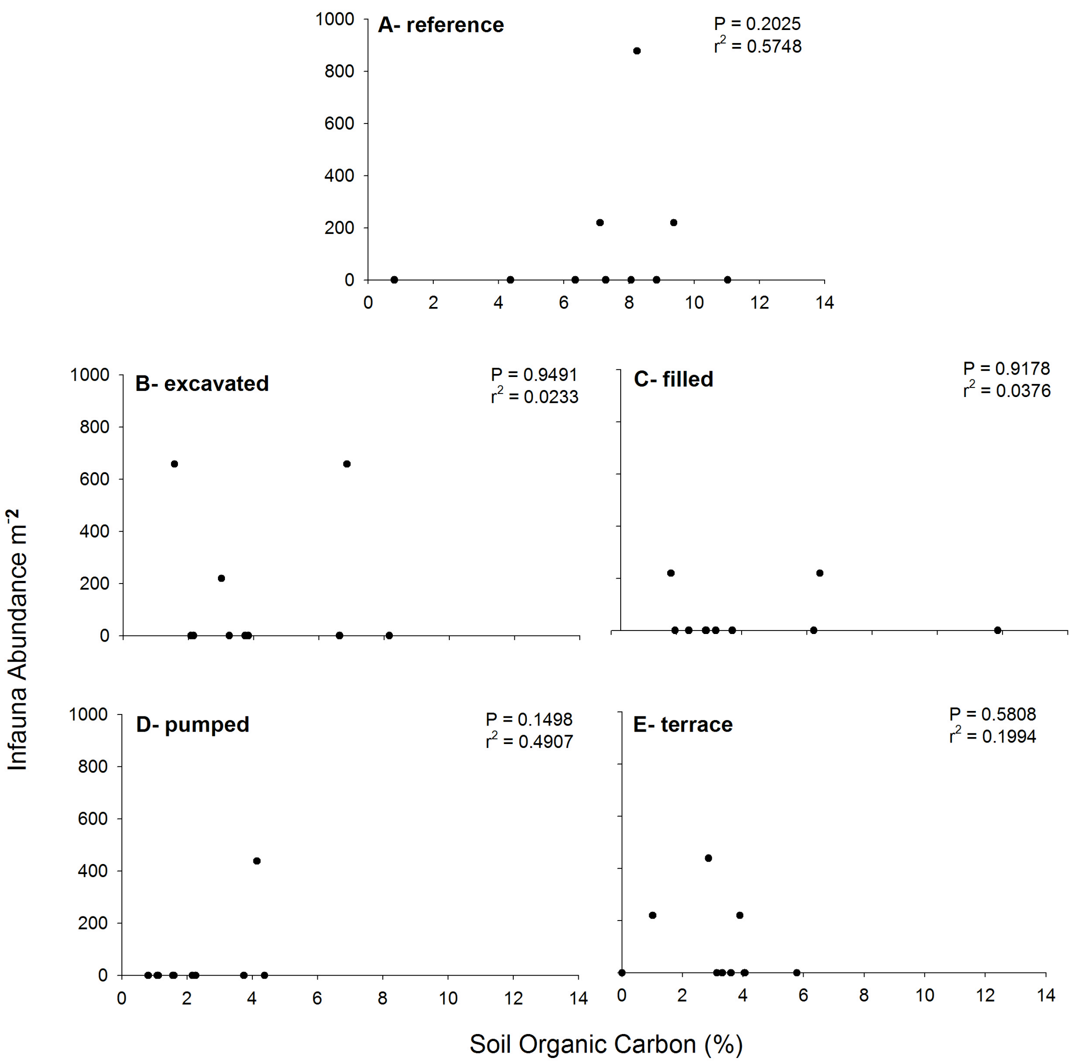

Fig. 5. Organic carbon (%) in reference (A), excavated (B), filled (C), pumped (D), and terrace (E) sites.

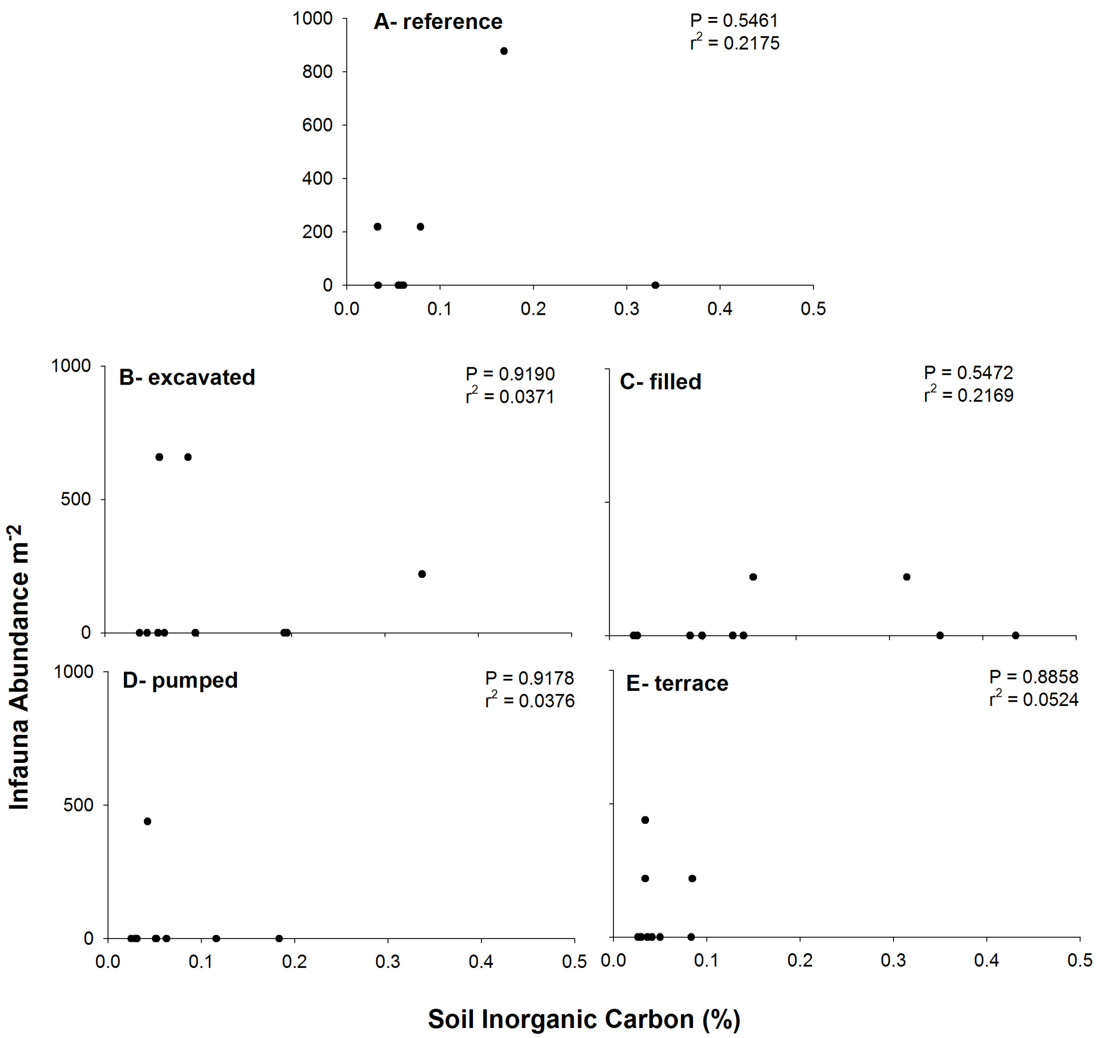

Fig. 6. Inorganic carbon (%) in reference (A), excavated (B), filled (C), pumped (D), and terrace (E) sites.

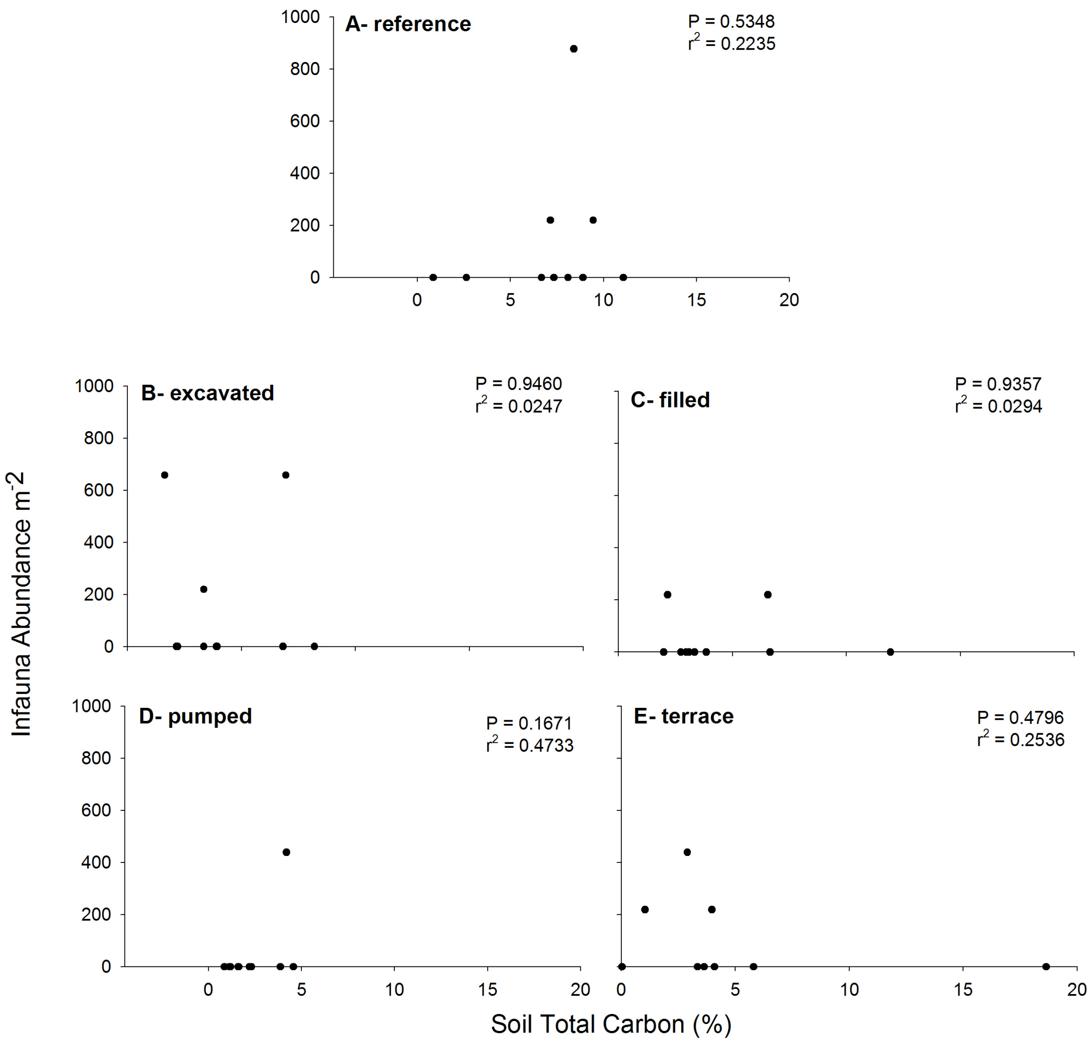

Fig. 7. Total carbon (%) in reference (A), excavated (B), filled (C), pumped (D), and terrace (E) sites.

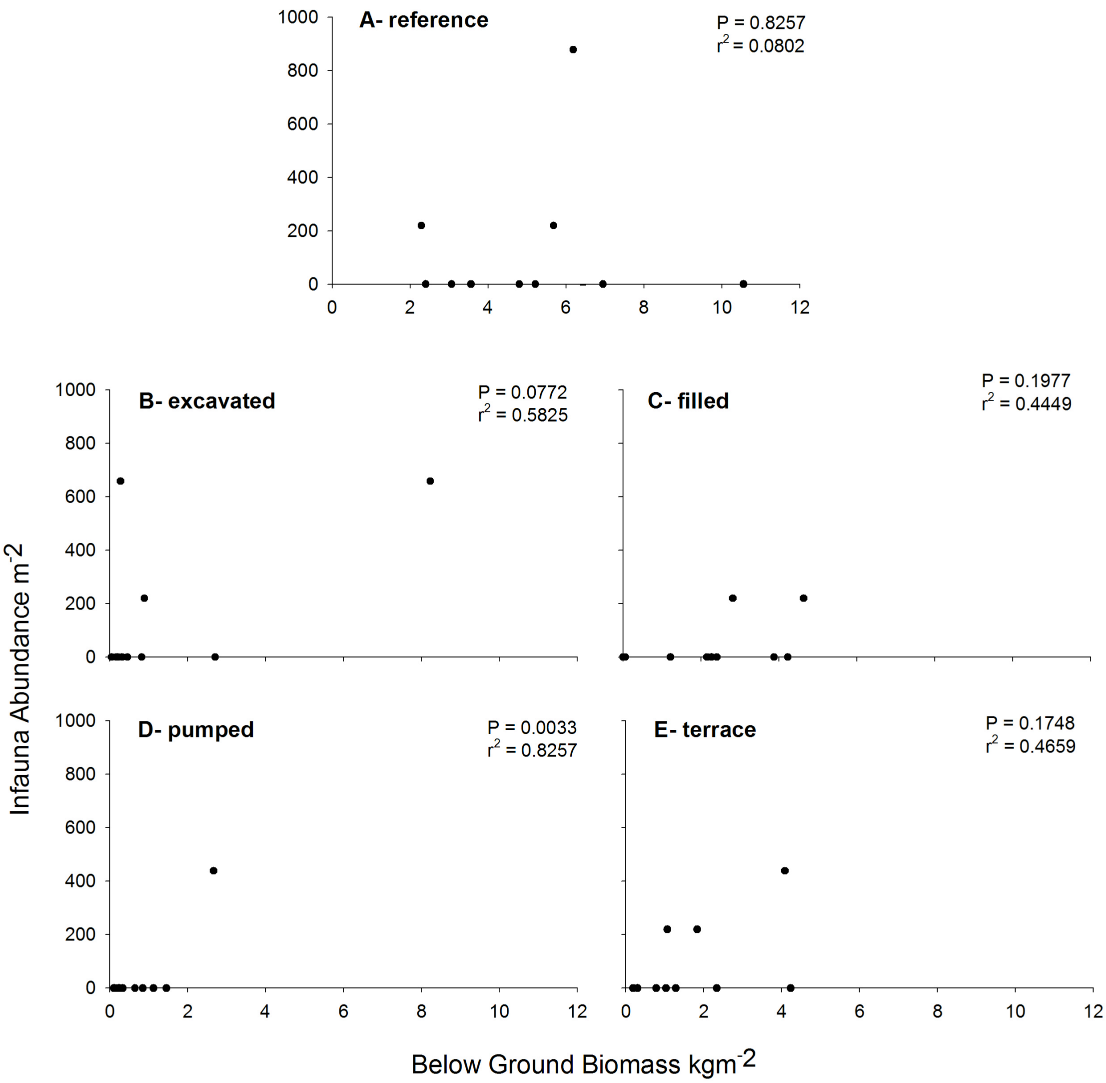

Fig. 8. Below ground biomass (kgm-2) in reference (A), excavated (B), filled (C), pumped (D), and terrace (E) sites.

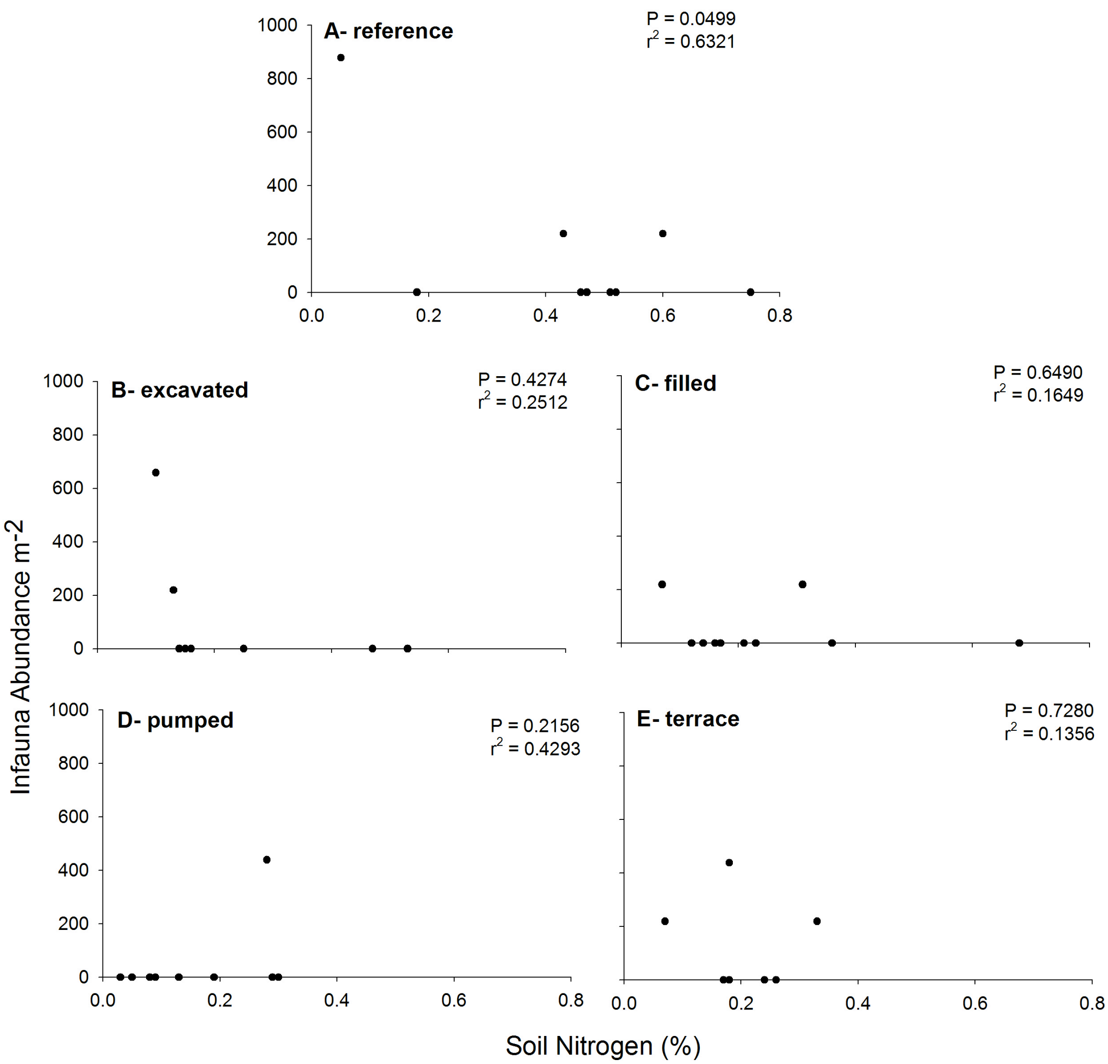

Fig. 9. Nitrogen (%) in reference (A), excavated (B), filled (C), pumped (D), and terrace (E) sites.

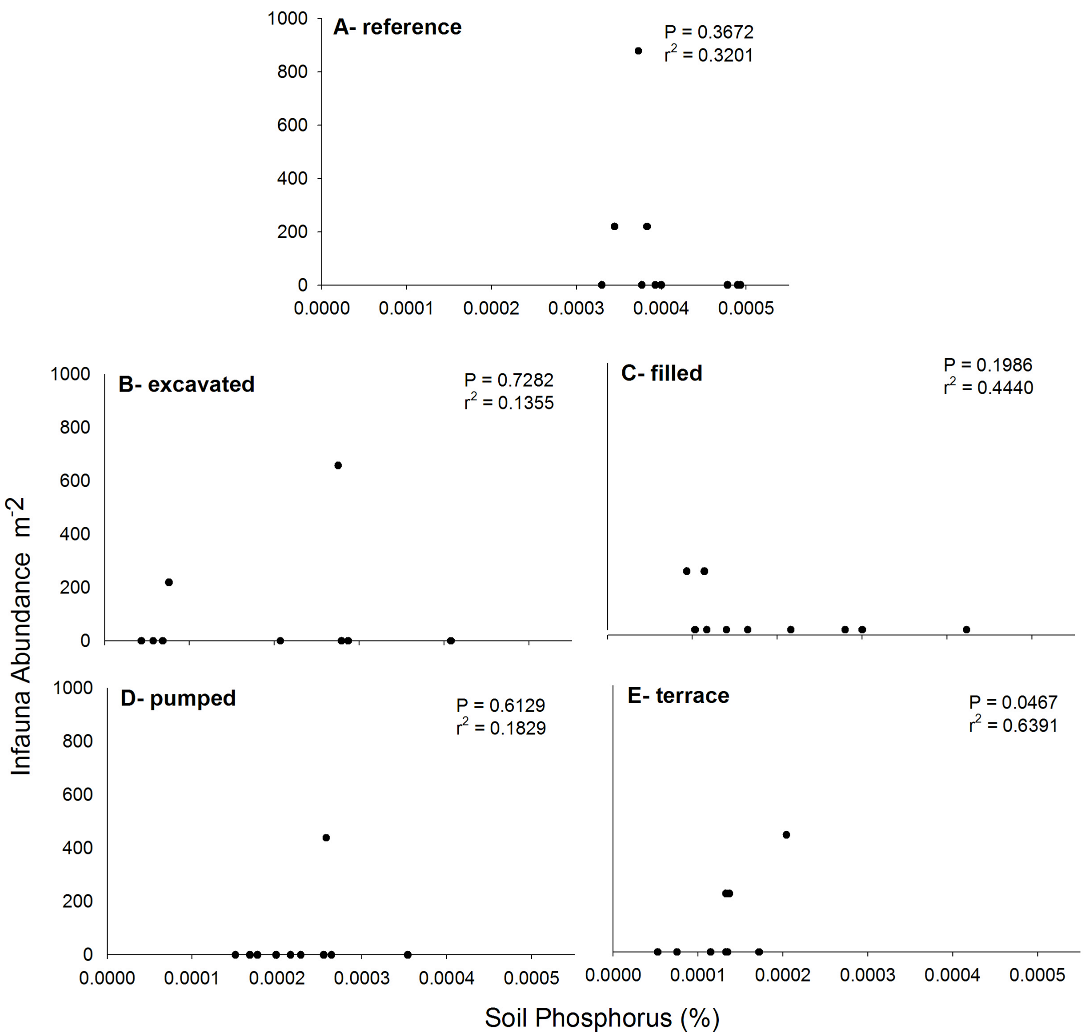

Fig. 10. Phosphorus (%) in reference (A), excavated (B), filled (C), pumped (D), and terrace (E) sites.

CHAPTER IV

DISCUSSION AND CONCLUSION

Restoration construction technique did not appear to impact infaunal densities or species richness. Additionally, infauna densities and species richness were not influenced by sediment characteristics which may explain their insignificant relationship with construction technique. In previous studies comparing restored and reference marshes, lower densities or species richness in the restored marsh have been attributed to lower organic content in the restored vs. reference marsh. The data collected in this study suggests that organic carbon content in the restored marsh sites are sufficient enough to support infauna communities comparable to the reference marsh. This conclusion is supported by Craft & Sacco 2003 who found that above the threshold of 0.5% (500 g m-2), infauna densities were consistently similar over a wide range of soil organic carbon levels (0.5 to 8%).

Similar infauna communities in the restored and reference marshes indicates that the recovery of restored marshes to reference conditions occurs in less than 4 years. My findings are similar with those from Craft & Sacco 2003 which showed that mean densities in restored marshes exceeded those in reference marshes after 8 years. Rapid recovery of the infauna community has also been reported for salt marshes along the coast of Southern California. Talley & Levin 1999 found that for *Salicornia* marshes recovery occurred in 5-10 years. In another study of *Spartina foliosa* marshes Levin & Talley 2002 reported that the infauna density in the restored marsh was 97% of that in the reference marsh in less than 3 years.

However, other studies of *Spartina alterniflora* marshes have argued that the infaunal community is much slower to develop. For example, Sacco et al. (1994) found that for restored marshes ranging in age from 1-17 years, infaunal densities were significantly lower than in the reference marshes. Levin et al. (1996) reported similar results for previously un-vegetated plots.

Total mean density in the reference marsh was 1532 indiv. m^{-2} which is lower than what has been reported for other *Spartina alterniflora* reference marshes (Table 2). Lower densities in my reference marsh may reflect the absence of oligocheates which are a major taxonomic group found in other studies. Oligochaetes are normally found in older marshes that have high organic carbon contents but have non-planktonic larvae with poor dispersal ability which increases the time required for recovery. The absence of oligochaetes could have facilitated a more rapid recovery but also suggests that conditions in the reference marsh are more degraded than in other studies.

When an evaluation of a restored marsh only includes vegetative components, recovery to reference conditions can appear to occur rapidly. While my data also suggests that the infauna community is quick to recover, it remains unclear if the conditions observed in the reference marsh are actually “healthy”. To more accurately describe the infaunal community and the factors influencing its development, it is recommended that monitoring at this site be continued.

Table 2. A comparison of mean infauna densities (m^{-2}) for reference and restored *Spartina alterniflora* marshes.

	Reference Marshes	**Restored Marshes**
Sacco et al. (1994) (1-17 yr. old)	18000 - 69000	16000 - 49000
Levin et al. (1996) (1-4 yr. old)	37000 - 65000	6000 - 47000
Craft et al. (1999) (20-25 yr. old)	19000 - 31000	31000 - 102000
Craft & Sacco (2003) (1-28 yr. old)	96000 - 157000	19000 - 145000
This study (3 yr. old)	1532	438 - 1754

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